BURBANK FIELD, OSAGE COUNTY, OKLAHOMA[1]

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ABSTRACT

Local structural conditions seem to have had little influence on the concentration of oil in this field. The area is an undulating monocline with a general dip to the west of about 35 feet to the mile. On the north and east sides of the field the oil-bearing sand grades in a short distance into an impervious shale, and this impervious shale prevents the oil from traveling farther up the dip. On the west and lower side of the field the oil is in contact with salt water. The oil production from each well also seems to be in proportion to the porosity of the sand in the immediate vicinity of the well, and has little if any relation to rock deformation. The shale barrier north and east of the field, therefore, has been the medium which retained the oil in its present position, and the porosity of the reservoir rock in the vicinity of each well has regulated that well's daily and ultimate production.

INTRODUCTION

The purpose of this paper is to discuss the following phenomena of this field: (1) The influence of structure on petroleum accumulation and concentration. (2) The relation between the porosity of the reservoir rock, and its oil content and production.

HISTORY

The first oil produced in Osage County was on its eastern line near Bartlesville, Oklahoma, and from the Bartlesville sand. This was found at a depth of 1,600 feet, and is near the base of the Pennsylvanian series. It is the most widespread and prolific of any oil sand in the county. The western limit of this sand, as now known, is a line running northeast and southwest nearly through the center of the county. Because developments started in the eastern part of the county and worked west, operators, after drilling many dry holes west of the center of the county, became reluctant to drill even on well-known structures in the western Osage, in which the Burbank field is located. It was not until the Marland Oil Company drilled in its first well in the Burbank field in May, 1920, in the SE. $\frac{1}{4}$ of Sec. 36, T. 27 N., R. 5 E., and the Carter Oil Company drilled in its first well in September, 1920, in Sec. 9, T. 26 N., R. 6 E., on

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two small anticlines, that the possibilities of the Burbank field were recognized by oil men in general. Since that time, thirteen sales of oil leases have been held by the Osage agency under the direction of the United States Government. At these sales, quarter-sections are auctioned to the highest bidder. So far the highest price paid has been $1,990,000 for the 160 acres in the NE. ¼ of Section 14, T. 27 N., R. 5 E., which was bought by the Midland Oil Company. Including the small part of the field which is in Kay County, 170 quarter-sections are producing. More than 130,000,000 barrels of oil have been extracted from the field. The production at present is 43,000 barrels daily from 2,000 wells. With one well to ten acres, the recovery to date averages 6,500 barrels per acre, while some leases have produced 20,000 barrels per acre. Figure 4 shows the production-decline curve of this field, the average production per well per day, and the average number of wells producing, from 1921 to date.

STRATIGRAPHY

The stratigraphy of Osage County has been so thoroughly worked by all of the oil companies operating in that district, and also has been described so completely in several publications,[1] particularly those of the United States Geological Survey[2] and the Oklahoma Geological Survey,[3] that space will not be taken here to describe the different members in detail. The surface rocks of the entire county, with the exception of a small area in the northwest part, are of Pennsylvanian age; Permian rocks overlie the Pennsylvanian conformably in that area. The contact of the Permian and Pennsylvanian extends northeast and southwest, through the eastern side of the Burbank field, so that most of the limestones used in working the surface structure are of Permian age. The total thickness of the Pennsylvanian series in Osage County is about 2,900 feet. It contains several different producing horizons in different parts of the county, some fields producing from several horizons at the same time. The Burbank field, however, is only producing commercially from the Burbank sand, which is near the base of the Pennsylvanian series at a depth of 2,800 feet in the southeastern part of the field, and a depth of 3,200 feet in the northwestern portion. It is a fine-grained, siliceous sand, having a calcareous cementing material. Its thickness ranges from 50 to 80 feet. Melcher's examination[4] shows the pore space to range from 13.7 per cent

[1] J. M. Sands, "Burbank Field, Osage County, Oklahoma," *Bulletin Amer. Assoc. Petrol. Geol.*, Vol. 8, No. 5 (1924), pp. 584–92.

[2] *U.S. Geol. Surv. Bulletin 686.* [3] *Oklahoma Geol. Surv. Bulletin 19.*

[4] "Texture of Oil Sands with Relation to the Production of Oil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8 (1924), pp. 716–74.

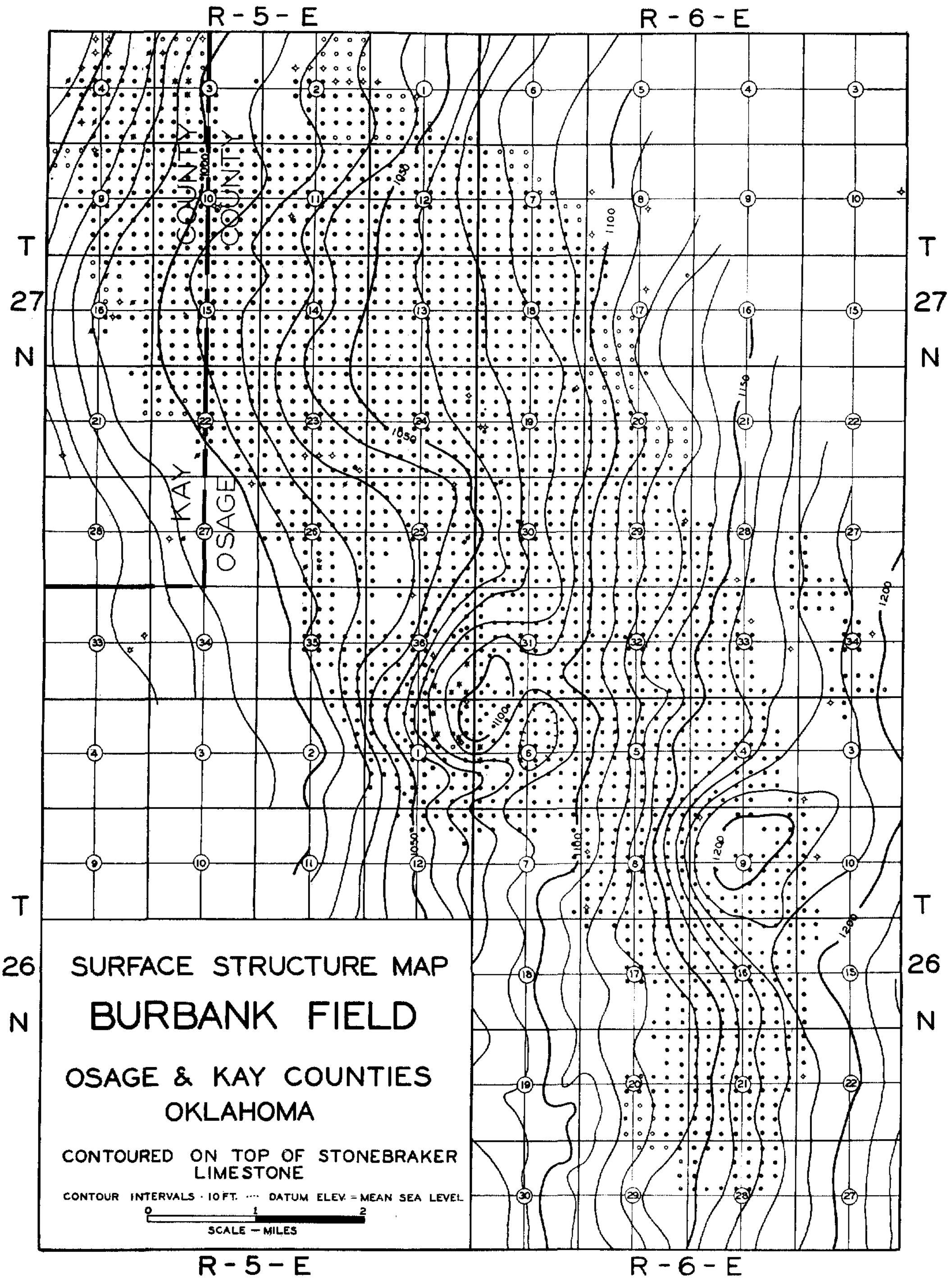
R-5-E
R-6-E
T
27
N
T
26
N
KAY COUNTY
OSAGE COUNTY
SURFACE STRUCTURE MAP
BURBANK FIELD
OSAGE & KAY COUNTIES
OKLAHOMA
CONTOURED ON TOP OF STONEBRAKER LIMESTONE
CONTOUR INTERVALS · 10 FT. ···· DATUM ELEV. = MEAN SEA LEVEL
0 1 2
SCALE — MILES
1000
1050
1100
1150
1200
R-5-E
R-6-E

FIG. 1

to 32.7 per cent by volume. The thickness of the sand is not uniform, and in some places there is a stratum of blue shale ranging from a few inches to 3 feet in thickness at about 50 feet from the base of the sand. Where the sand is thickest, about 80 feet, the sand above this blue shale is about 30 feet thick and carries nothing but gas. It is quite probable that the range in the thickness of the Burbank sand is caused altogether by the range in thickness of this upper member, and that, where the oil is found at the surface of the sand, this upper member is very thin, or in some places entirely absent. Though the lower 50 feet of the sand is generally a pure sand without any shale breaks, its porosity and content of calcareous material differ, so that the sand is probably not productive throughout its total thickness. The production comes from three or four different zones encountered at different depths, and it is quite probable that not more than two-thirds of the total thickness is productive.

Stratigraphically, the Bartlesville and the Burbank sands in Osage County, Oklahoma, and the Rainbow Bend and Fox Bush sands in Kansas, seem to be at about the same horizon. The Bartlesville sand, however, is a blanket formation covering a large part of northeastern Oklahoma and a small part of southeastern Kansas, while the other three sands mentioned have much smaller areas and may be in the form of large lenses. In the vicinity of the Burbank field, the Burbank sand has been encountered as a water sand considerably outside the field in several localities, and within the last year the Kewanee pool, 1 mile east of Burbank production, and the Fairfax pool, located 6 miles south of the Burbank pool, have developed production in this sand. Whether or not these two pools ultimately will be found to connect with the Burbank field and also whether or not the sand of the Fairfax pool will be found to continue south to connect with the Bartlesville sand, will remain for further development to discover. There is a distance, however, of 18 miles between the western edge of the Bartlesville sand near Pawhuska and the eastern edge of the Burbank sand in that field proper.

The Burbank sand is separated from the "Mississippi lime" below by 40–70 feet of blue Cherokee shales. The "Mississippi lime" here is a series of hard, semicrystalline, blue limestone beds, divided by more shaly or chalky, softer members. The total thickness is 320 feet. Beneath this is 130 feet of black Chattanooga shales, beneath which is the "Wilcox" sand. In this field, this sand is rather fine grained and calcareous, but is sufficiently porous to have a showing of oil and a hole full of water. This oil was encountered in the Carter well in Sec. 9, T. 26 N., R. 6 E., which is located in the highest part of the field. This well should have been a

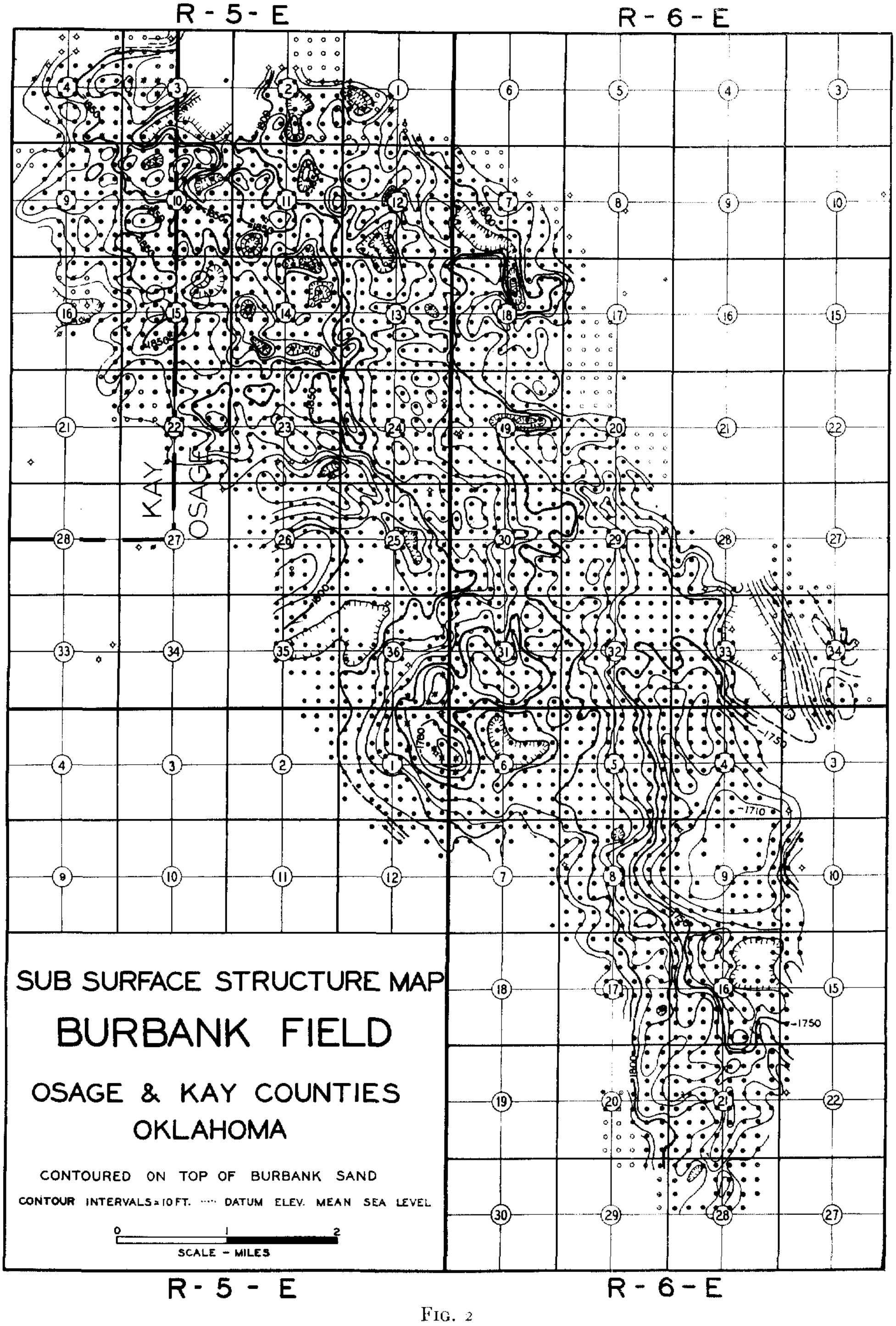
R - 5 - E
R - 6 - E
KAY
OSAGE
SUB SURFACE STRUCTURE MAP
BURBANK FIELD
OSAGE & KAY COUNTIES
OKLAHOMA
CONTOURED ON TOP OF BURBANK SAND
CONTOUR INTERVALS = 10 FT. DATUM ELEV. MEAN SEA LEVEL
SCALE - MILES
-1750
-1710
-1750
R - 5 - E
R - 6 - E

Fig. 2

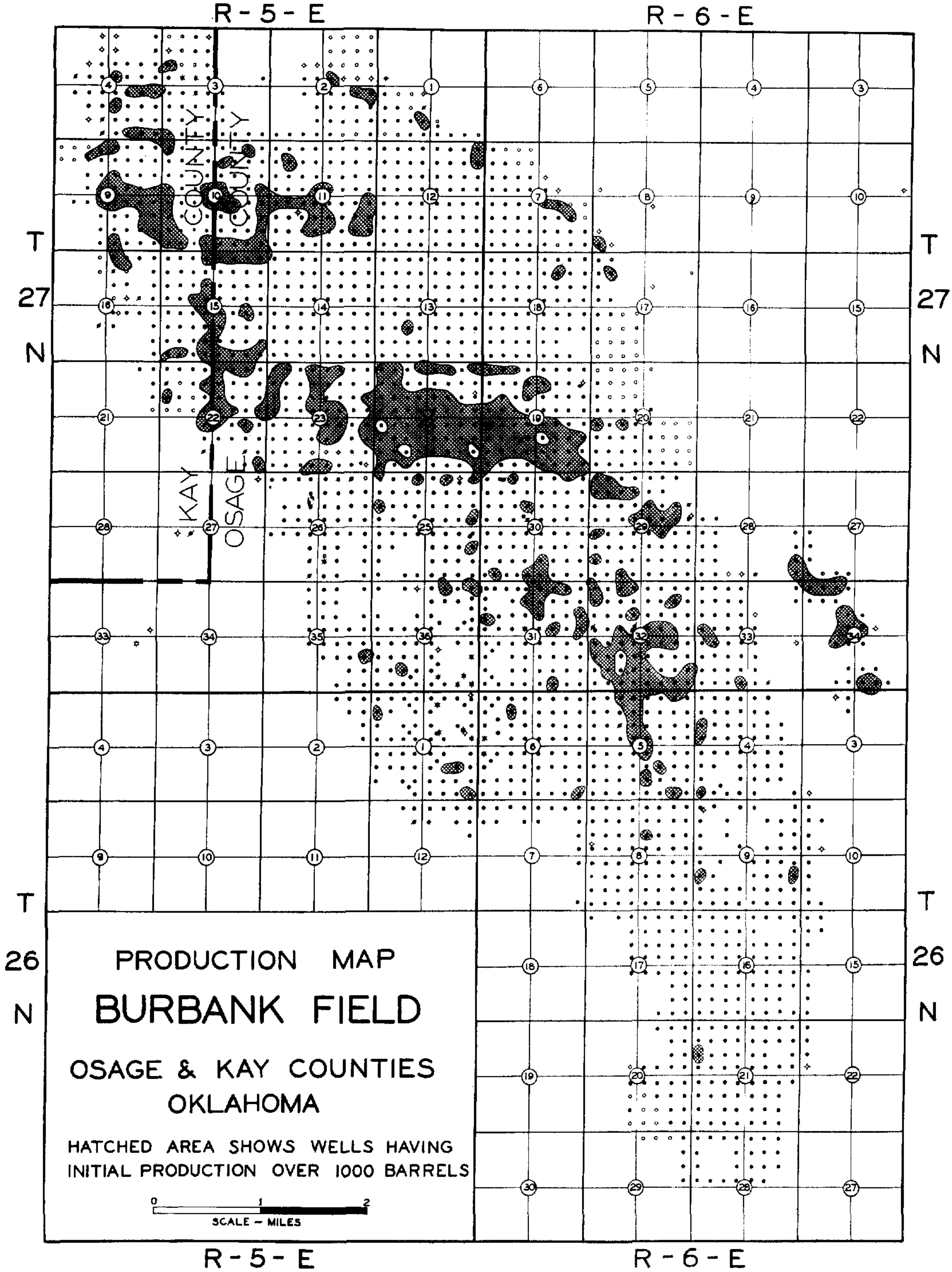
R-5-E
R-6-E
T 27 N
T 26 N
KAY COUNTY
OSAGE COUNTY
PRODUCTION MAP
BURBANK FIELD
OSAGE & KAY COUNTIES
OKLAHOMA
HATCHED AREA SHOWS WELLS HAVING
INITIAL PRODUCTION OVER 1000 BARRELS
0 1 2
SCALE – MILES

FIG. 3

splendid test for production in this sand. It is therefore improbable that any "Wilcox" production will be found in this field, although, because of the existence of this sand in this district and the showing of oil in it, there is very good reason to suppose that in districts in this vicinity where conditions have been more favorable for oil depositions in this sand, there should be production developed in it. Beneath the "Wilcox" sand is 860 feet of siliceous lime. This lime is composed of thick, cherty members of hard gray siliceous limestone interbedded with thinner members of a more shaly or sandy nature. No oil or gas was encountered in it. Below the siliceous limestone is granite. This granite is much the same class as that found in the granite ridge extending through Kansas and the northwest corner of Osage County. The granite was encountered in only one well in the field, that being the well of the Carter Oil Company located in the northwest corner of the NW. ¼ of Sec. 9, T. 26 N., R. 6 E. The granite was encountered at 4,240 feet. A type well log of the field is shown in Figure 5. The lower 700 feet is taken from the Carter Oil Company's well.

STRUCTURAL CONDITIONS

The Burbank field is included in the territory situated on the western flank of the great regional uplift which has for a center the Ozark Plateau. This west flank includes northwestern Arkansas, northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. The strata in Osage County dip a little north of west at the rate of about 30 feet to the mile, this dip being changed and reversed in different localities, according to local structure conditions.

Figure 1 shows surface structural conditions in the Burbank field, using the Stonebreaker limestone as datum. The general dip is about 35 feet to the mile, approximately due west. The only reversals developed are a small dome with about 20 feet of closure in Sec. 9, T. 26 N., R. 6 E. and a still smaller dome with 10 feet of closure at the intersection of T. 26–27 N. and R. 5–6 E., the latter being 100 feet lower than the former.

Figure 2 shows structural conditions developed on top of the Burbank sand. A comparison of these two figures shows a much greater deformation of the subsurface structure than of the surface. There are several small domes and synclines, and the two small domes shown on the surface have had their closure greatly increased. The one in Sec. 9, T. 26 N., R. 6 E. shows 50 feet of closure, while in the one at the intersection of T. 26–27 N., and R. 5–6 E. there are 35 feet of closure.

The structural conditions of the Burbank field may then be called an undulating monocline dipping at the rate of about 35 feet to the mile in a westerly direction, with the largest deformation being the previously

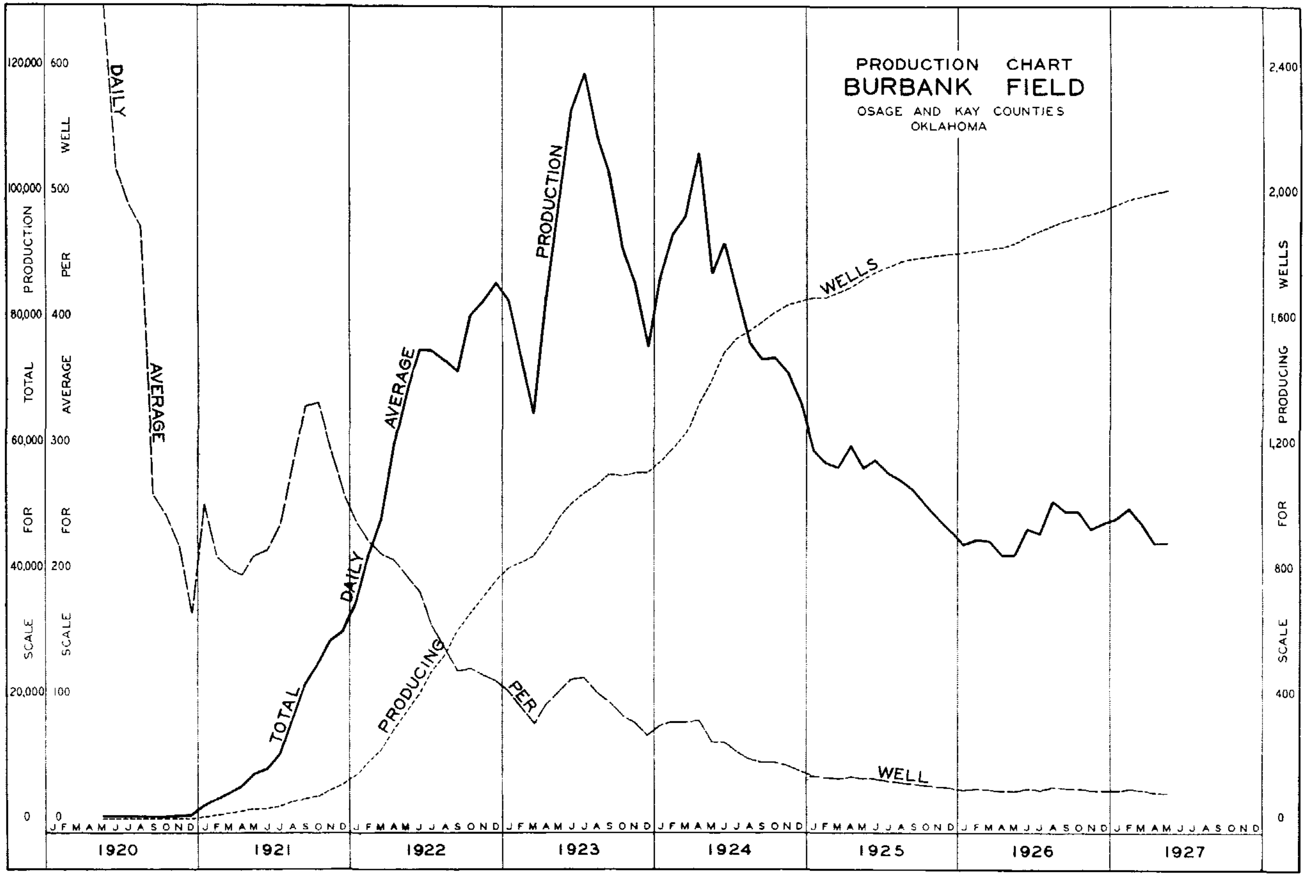
PRODUCTION CHART
BURBANK FIELD
OSAGE AND KAY COUNTIES
OKLAHOMA
SCALE FOR TOTAL PRODUCTION
SCALE FOR AVERAGE PER WELL
SCALE FOR PRODUCING WELLS
TOTAL DAILY AVERAGE PRODUCTION
DAILY AVERAGE PER WELL
PRODUCING WELLS
1920
1921
1922
1923
1924
1925
1926
1927

FIG. 4.

mentioned anticlines which are at the southeast end of the field. This monoclinal condition, deformed by small reversals, is general throughout the territory.

OIL CONCENTRATION

As far as it has been possible to determine, structural conditions have only a secondary and minor influence in the concentration of oil in this field. The oil sand saturation and the production of wells therefrom seems to be in proportion to the porosity of this sand.

Melcher states:[1]

> The production-porosity curve of the Burbank field shows evidence not only of an interesting relation between the average percentage of pore space of the producing sand and the greatest production for 24 hours of the wells, but also indicates that in the Burbank field the greatest rate of production will be in areas of largest average percentage of pore space, regardless of relation to geologic structures. The curve indicates also that an average pore space of about 13 per cent is the lower limit for commercial production of the producing sand in the Burbank field.
>
> The close relation between average percentage of pore space and maximum production for 24 hours of the wells is largely due to the small ranges of variations in most of the other physical factors, as structure, size of grain, pressure and temperature, specific gravity, and viscosity of the oil.

The highest points structurally in the field are among the places of smallest oil production, and, while more than the usual amount of gas is found with the oil at these places, yet they are not even the most productive portions of the field for gas production. The most prolific portions of the field for oil production are in the northwest part,

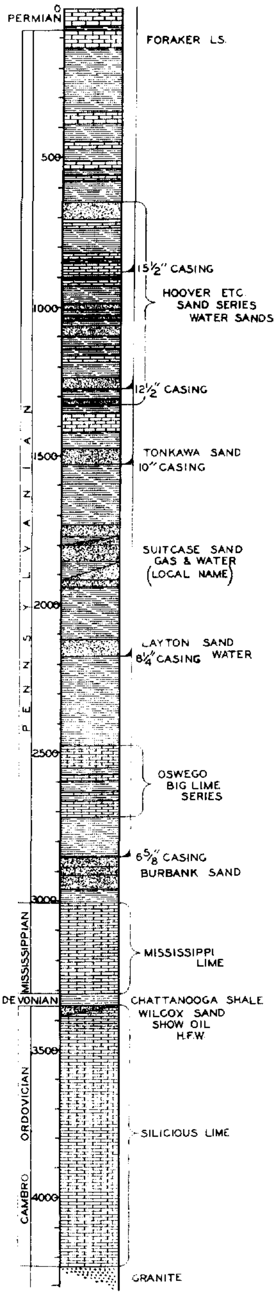

FIG. 5.—Type log, Burbank field, Osage and Kay counties, Oklahoma.

[1] "Texture of Oil Sands with Relation to the Production of Oil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8 (1924), pp. 716–74.

several miles from the highest point structurally, and from 100 to 150 feet below it. The production of the wells changes in a few hundred feet from that of a very large well to a comparatively small one, depending on the porosity of the sand in the two wells. The most porous portions of the sand seem to be in irregular patches, mostly disconnected and in fairly small units, scattered through the whole field, but of large size and more numerous in the northwest portion. This is shown in Figure 3.

On the northern and eastern sides of this field the producing sand grades abruptly into an impervious sandy shale. This change of lithological character has been the primary reason for oil concentration, oil and gas having traveled up the slope in an easterly direction until they could go no farther. Some gas separated from the oil into portions of the reservoir rock, which was not porous enough to admit the oil, this concentration of gas being particularly noticeable on the tops of the two main structures and in places on top of the producing horizon where it had become thickened on top with a fine-grained, almost impervious sand member. Gas also was present in large quantities in the extreme northern end of the field, which is the lowest part of it, the gas being found structurally below the oil where the producing sand was so fine-grained that the oil or water could not penetrate it, but where the pore space was sufficient to allow the gas to accumulate.

Another peculiar feature of this field is that, besides the irregularly spaced and shaped porous portions of the producing sand scattered throughout the field, there is a very porous and productive zone strung along the northeastern extremity of the field. This zone is not more than a quarter of a mile wide and grades in a very short distance into the impervious shale which limits the area of the field in that direction. The writer is not conversant enough with all of the theories of deposition, sedimentation, and cementation of rocks to be sure of the cause of this porosity, but believes that it is probably caused by the leaching out of the calcareous cementing material after deposition by a current of water directed in this course by the impervious nature of the rock to the northeast, and that after this leaching the pore space was filled with oil.

To sum up, therefore, it seems that oil and gas have been trapped in the Burbank field because they could not travel any farther east, and that in so accumulating they were concentrated in the most porous portions of the reservoir rocks. It was, therefore, the impervious barrier on the eastern side of the field and the porosity of the reservoir rock in the field that were the controlling factors in the oil concentration, and not the structural conditions.